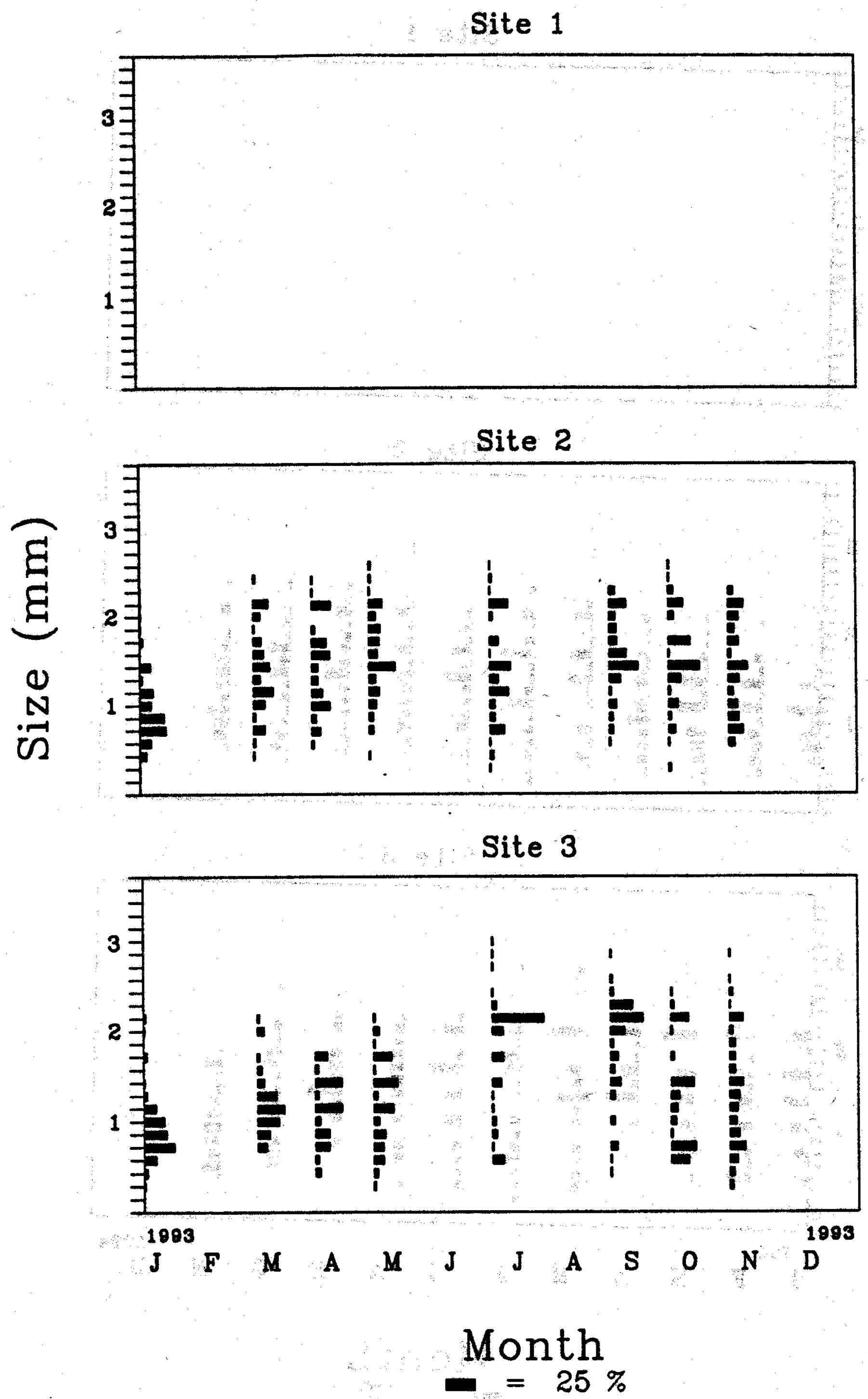

Figure 3d. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for each sample).

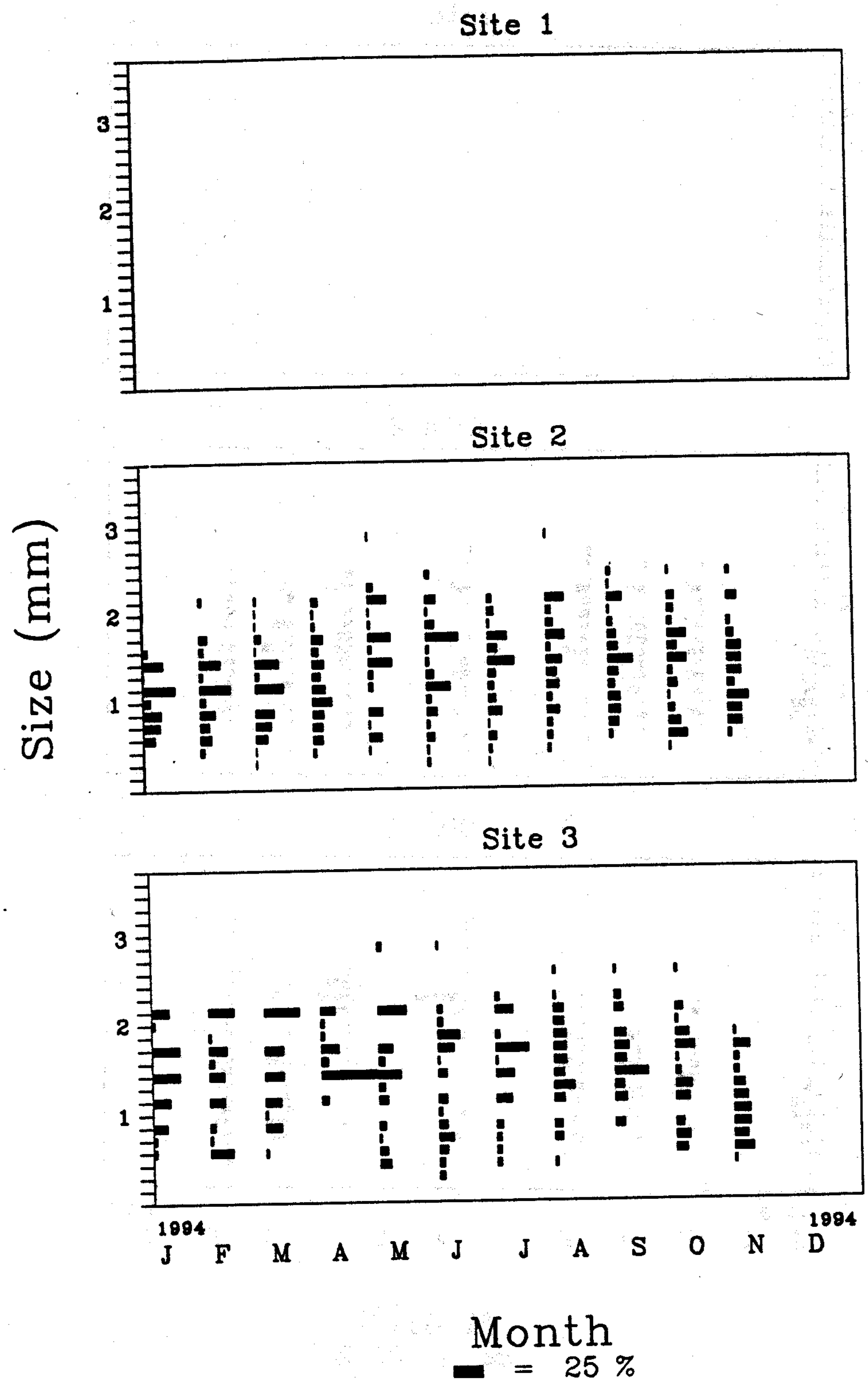

Figure 3e. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).

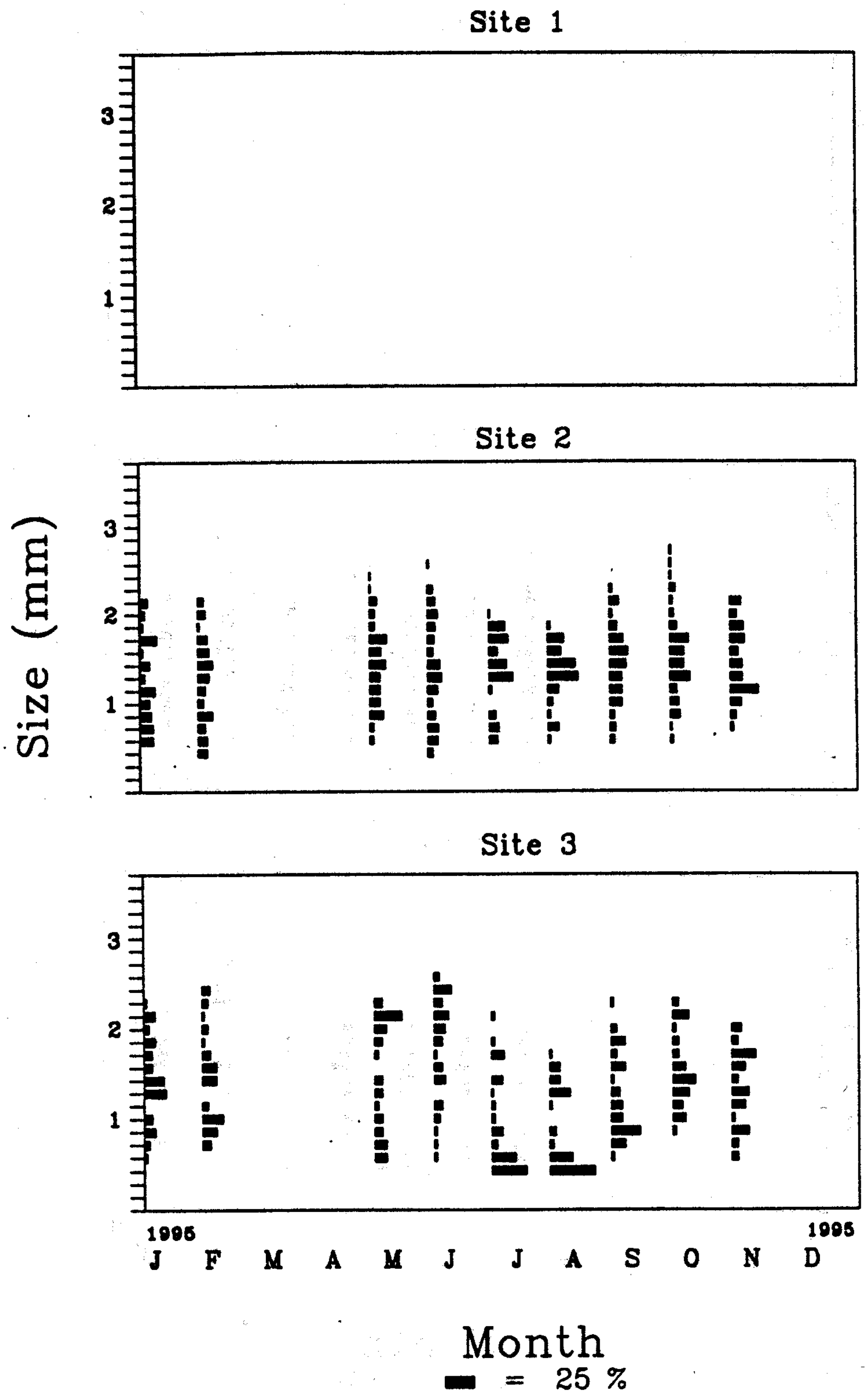

Figure 3f. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).

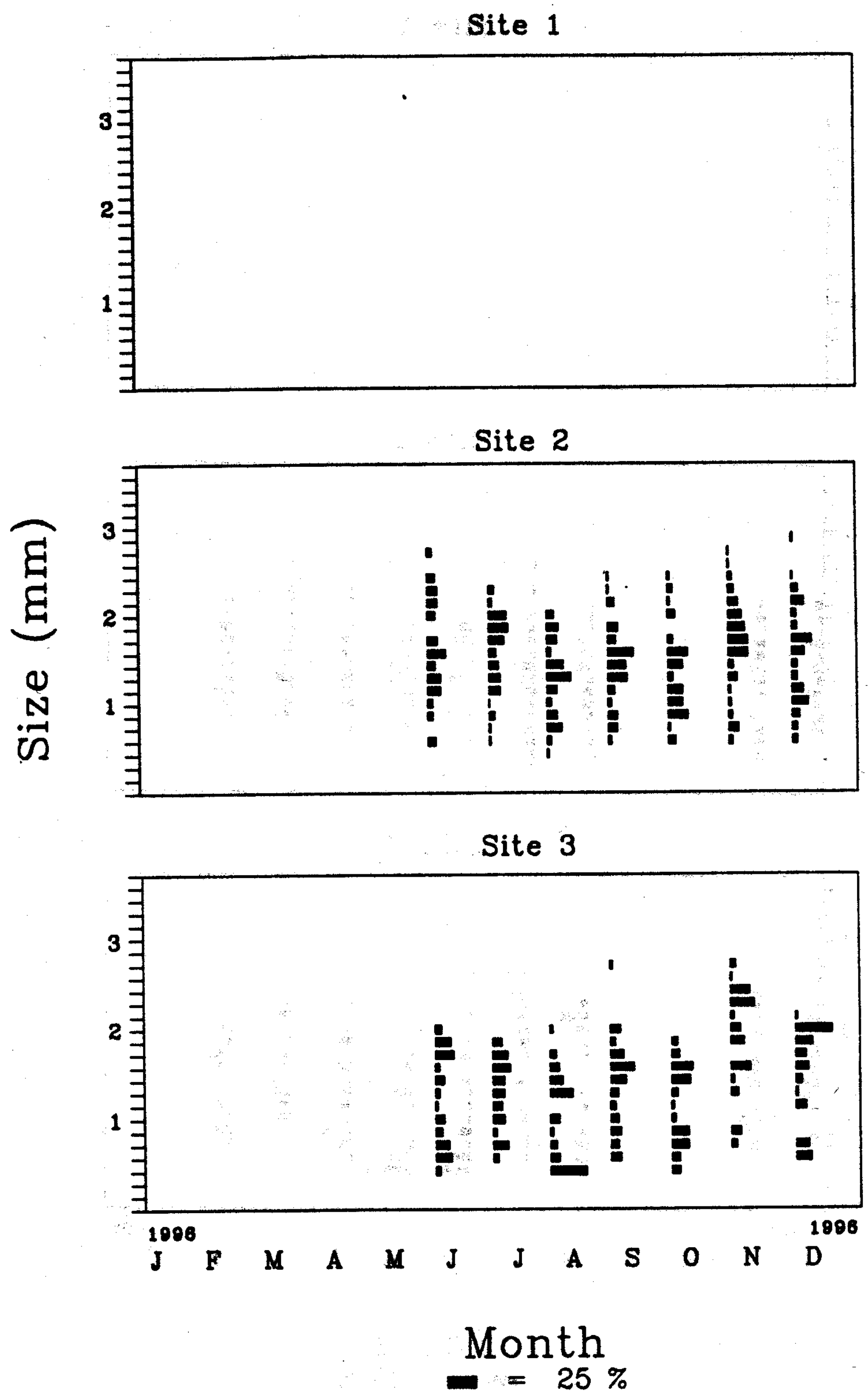

Figure 3g. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).

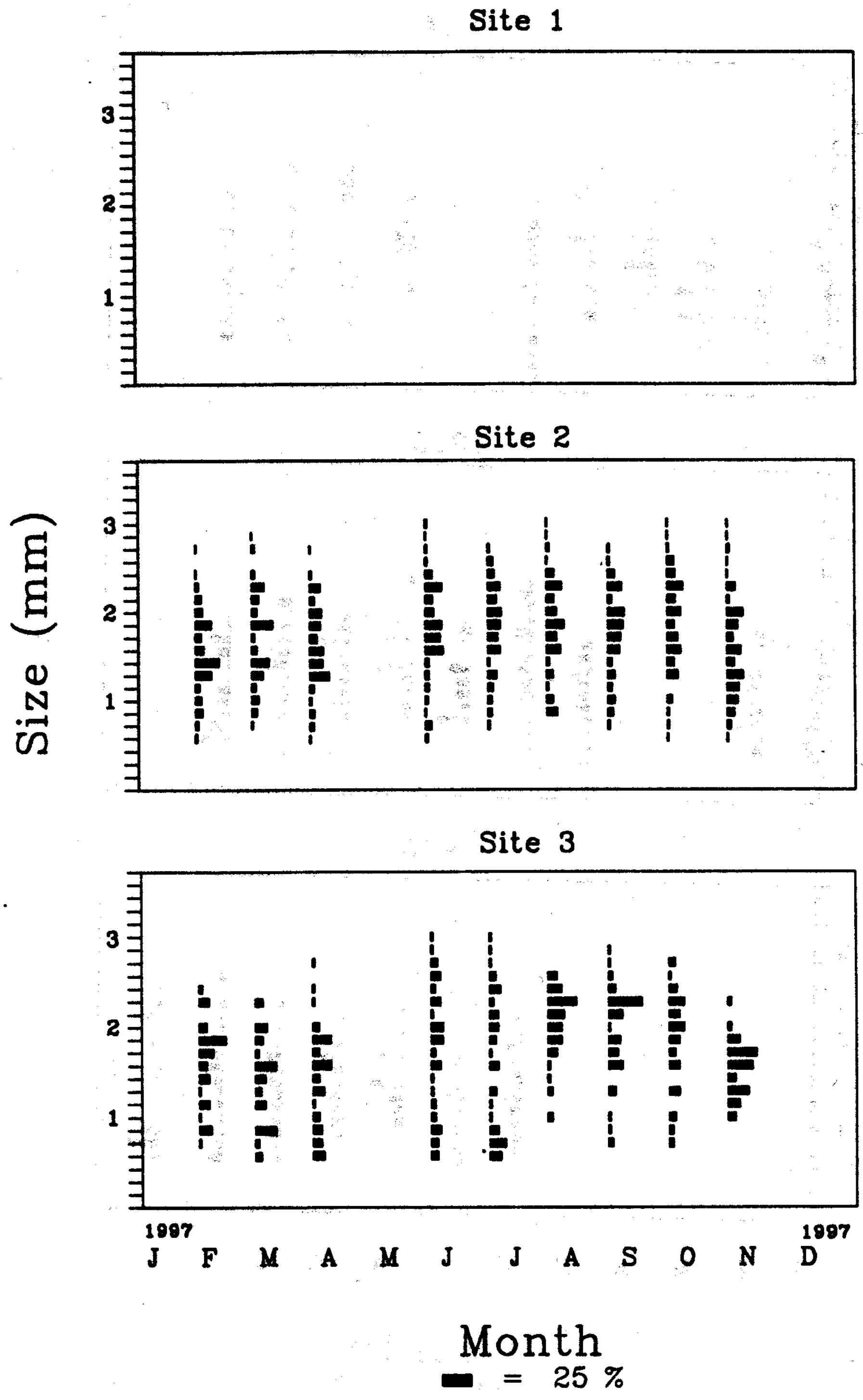

Figure 3h. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).

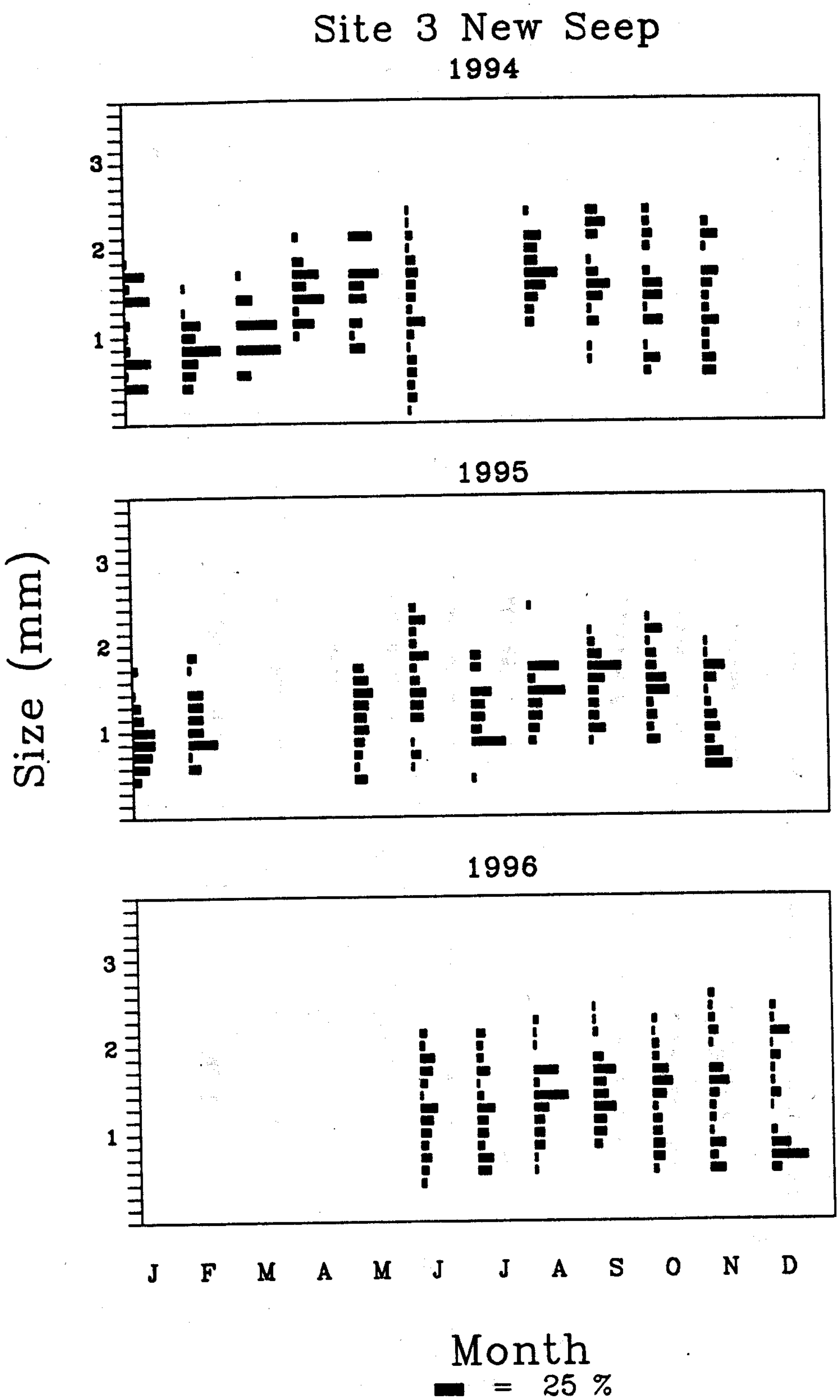

Figure 4a. Size histograms for the Bruneau Springsnail study site 3 New Seep. Horizontal tick marks represent 0.14 mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=50 for each sample).

Site 3 New Seep

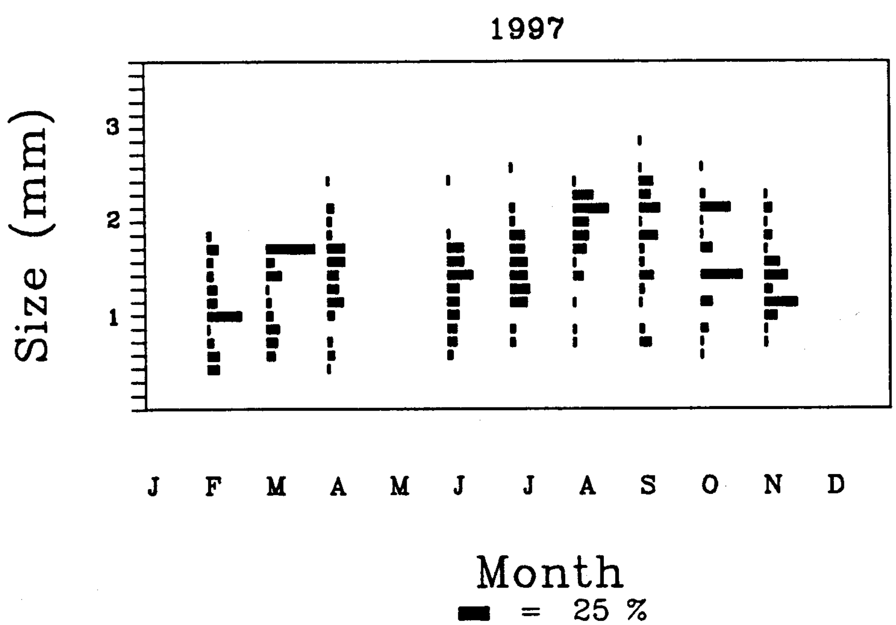

Figure 4b. Size histograms for the Bruneau Springsnail study site 3 New Seep. Horizontal tick marks represent 0.14 mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=50 for each sample).

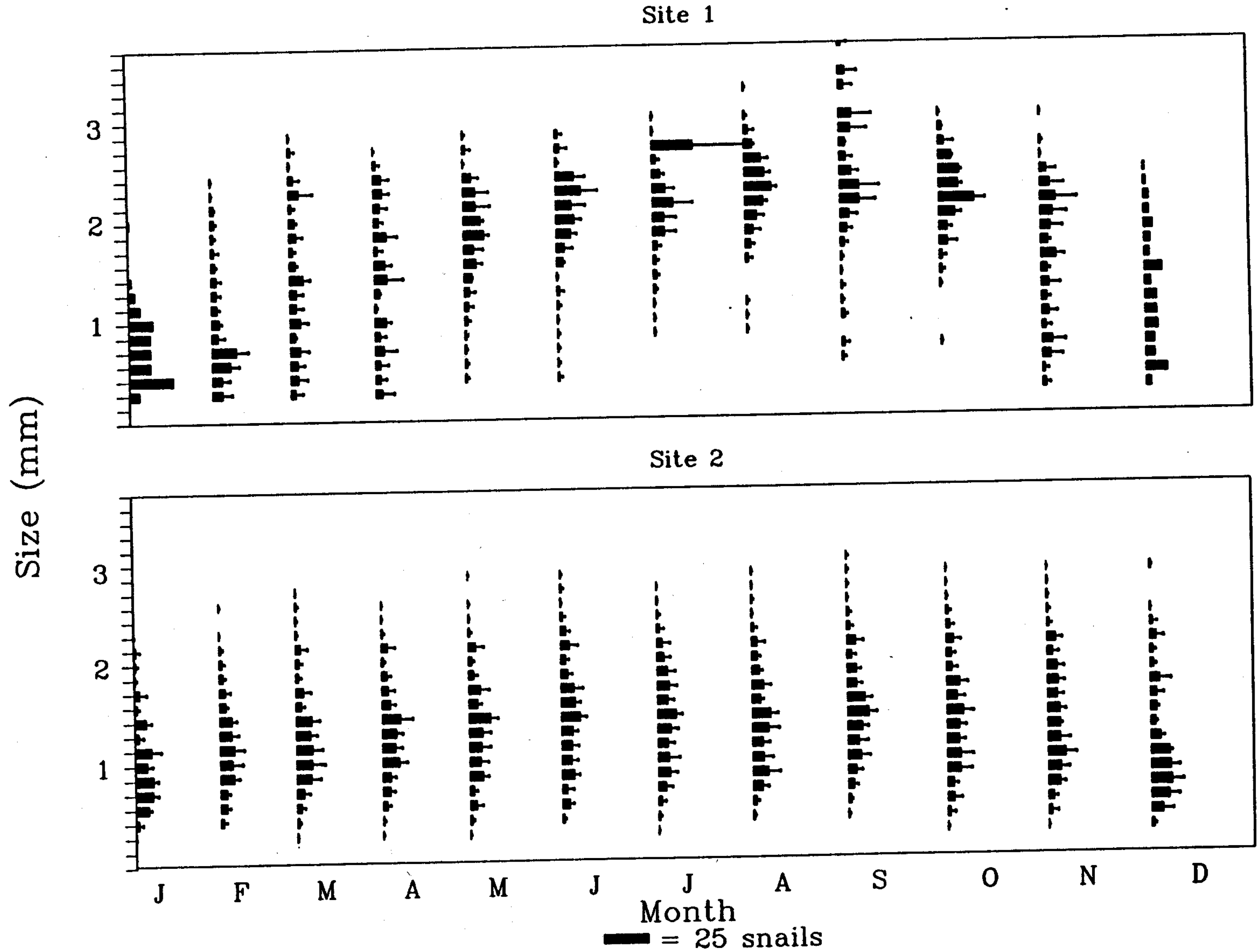

Figure 5a. Size histograms for Bruneau Springsnail study sites 1 and 2 based upon data from 1990-1997. Horizontal tick marks represent 0.14mm size classes. Error bars represent one standard deviation from the mean. Figures lacking error bars did not have enough sets of data to determine standard deviations.

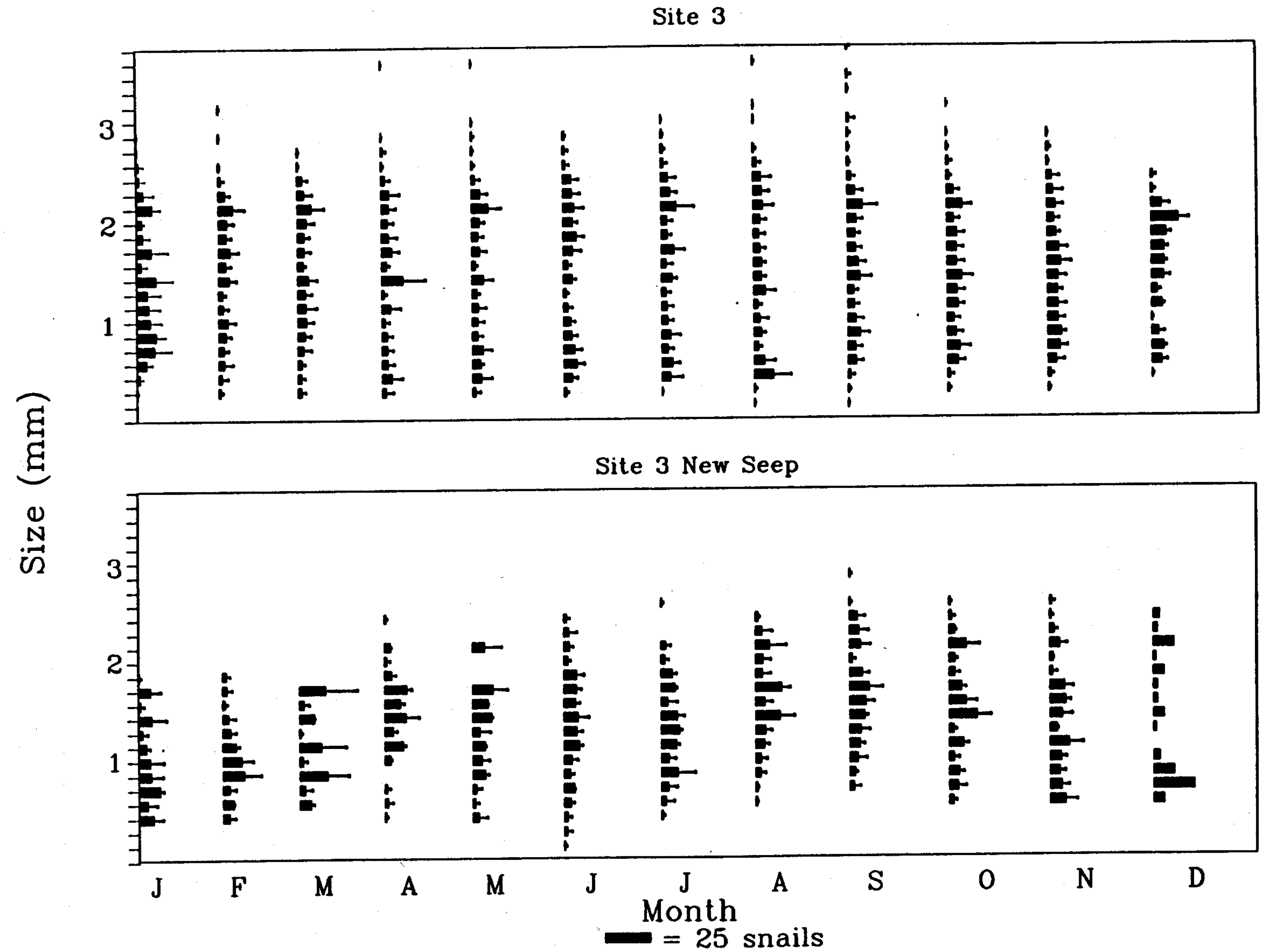

Figure 5b. Size histograms for Bruneau Springsnail study sites 3 and 3 New Seep based upon data from 1990–1997. Horizontal tick marks represent 0.14–mm size classes. Error bars represent one standard deviation from the mean. Figures lacking error bars did not have enough sets of data to determine standard deviations.

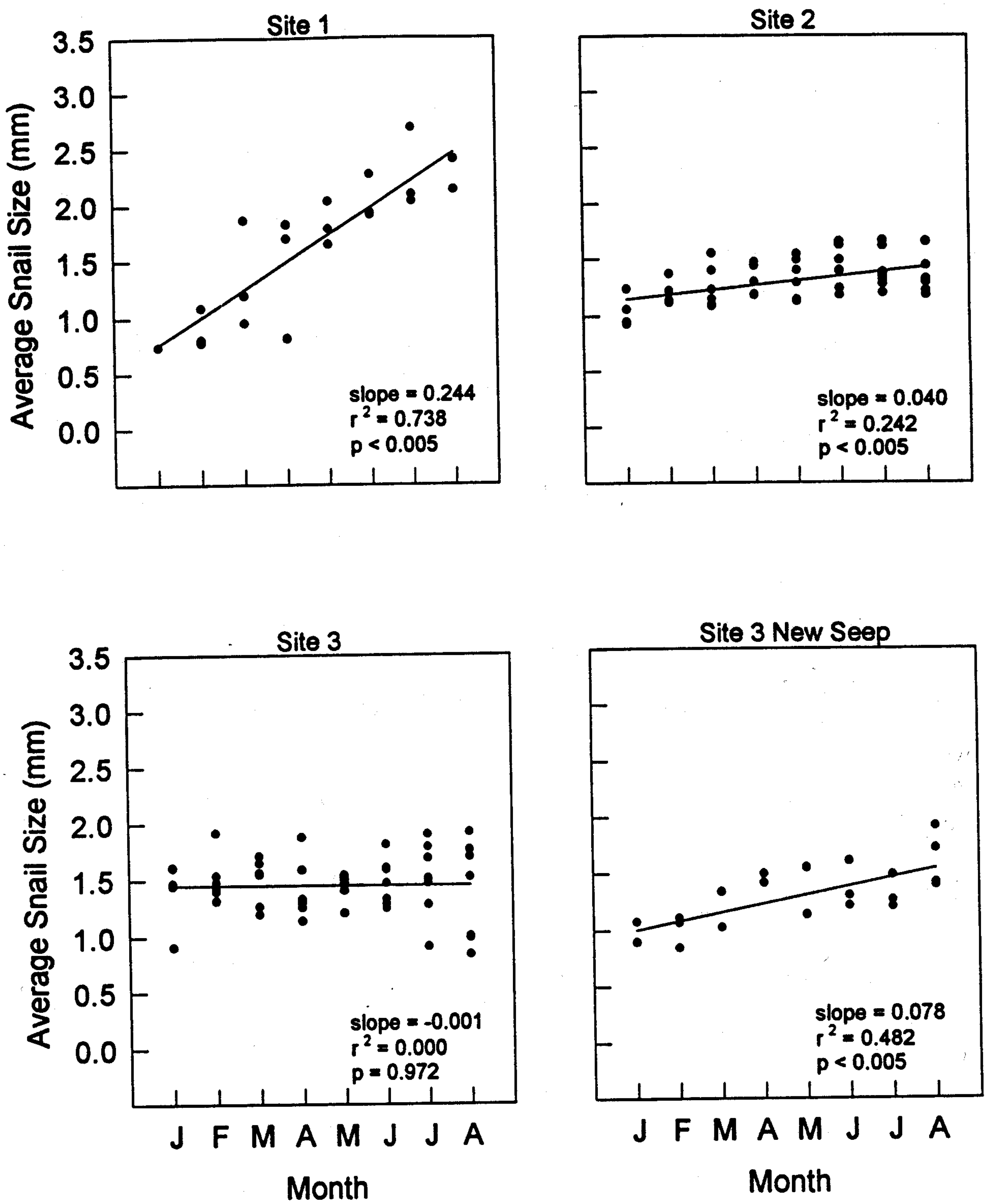

Figure 6. Estimated Springsnail growth rates based upon average monthly size (mm) at study sites 1, 2, 3-OS, and 3-NS. See text for explanation of months chosen for analyses. Years included in the analyses were 1990 - 1992 (Site 1), 1990 - 1997 (Sites 2 and 3-OS), and 1994 - 1997 (Site 3-NS).

Mean size distribution data for the Springsnail population at Site 3-OS did not show clear trends associated with season over the past eight years (Fig. 5b). Individuals appeared to be dispersed fairly evenly across the size classes each month.

Site 3-NS

Between February and November 1997, the Springsnail population at Site 3-NS also lacked any clear trends in size distribution, although the population appeared to mature in August and September (Fig. 4b). Because this agreed with the trend at Site 3-OS (Fig. 3h), it is likely that a cohort of individuals matured during this period at both Site 3 study sites (OS and NS). Mean size distribution data suggested that the New Seep population maintained a fairly even distribution of individuals across the different size classes during all seasons and that the development of cohorts at both Site 3 seeps might not be a frequent occurrence. There was a slightly higher proportion of juveniles present at the New Seep during the cold months (January-March and December) (Fig. 5b). Also, there was a noticeable lack of individuals > 2.5 mm at Site 3-NS relative to the other monitoring sites.

Comparison of Average Monthly Snail Sizes Among Sites

An analysis of the average monthly snail sizes, based upon data collected between 1990 and 1997 (Fig. 6), revealed distinct differences in population life histories among the study sites. The slopes of the linear regressions calculated in Figure 6 were used as estimates of site-specific population growth rates. Snails at Site 1 appeared to grow as a distinct cohort. The water temperatures at Site 1 were the warmest (often above the thermal maximum temperature of 35°C (Fig. 10; Mladenka 1992)). Recruitment probably only occurred in the cooler winter months, based upon the small average snail sizes found between January and March. The slope of the regression line for Site 1 (0.244; $p < 0.005$) (Fig. 6) was strongly positive and appeared to represent a gradual aging of the population between January and August. September was the month when another cohort appeared to begin its development in Hot Creek (Fig. 5a), so Figure 6 does not take the months of September through December into account. Site 1 also had the largest average snail size of all the study sites (Fig. 6). The populations at the other sites (2, 3-OS, and 3-NS) did not exhibit as strong trends as Site 1 (analyzed between January and August for comparative purposes). Both Site 2 and Site 3-NS had significant regression lines ($p < 0.005$) with slightly positive slopes (0.040 and 0.078, respectively). Site 3-OS data was very scattered and even exhibited a slightly negative trend between January and August (slope = -0.001, $p = 0.972$).

Springsnail Population Fluctuations

Site 1 (Hot Creek)

Storm flow in Hot Creek during July 1992 resulted in major channel scouring and sediment loading. As a result, Indian Bathtub was filled with sediment. Consequently, the Hot Creek (Site 1) population of *P. bruneauensis* was reduced to nearly zero (Robinson et al. 1992). Snails have not been found in Hot Creek since 1993. It is likely that *P. bruneauensis* has been extirpated from this site (Fig. 7; Royer and Minshall 1993). A stream-side refugium that had retained snails (<10 individuals) in the past (Robinson et al. 1992) continued to do so in 1993. Royer and Minshall (1993) noted that in May 1993 this refugium became overgrown with dense terrestrial vegetation. These conditions have persisted, inhibiting observations, since that time. A more intensive search of this area on 21 July 1997 revealed, again, a small population of Springsnails at this small rockface seep (approx. 10 x 10 cm) that is 1.8 m from Site 1 (Hot Creek). This finding will be discussed in a later section of the report.

Site 2 (Upper Spring Rockface)

The highest Springsnail density at Site 2 in 1997 was 12,081 snails/m^2 in April and the lowest density was 5663 snails/m^2 in October (Fig. 7). These numbers fell within the range of data from previous years. Densities at Site 2, between 1990 and 1997, have generally been higher than those at the other study sites, although monthly estimates have exhibited great variability (Fig.

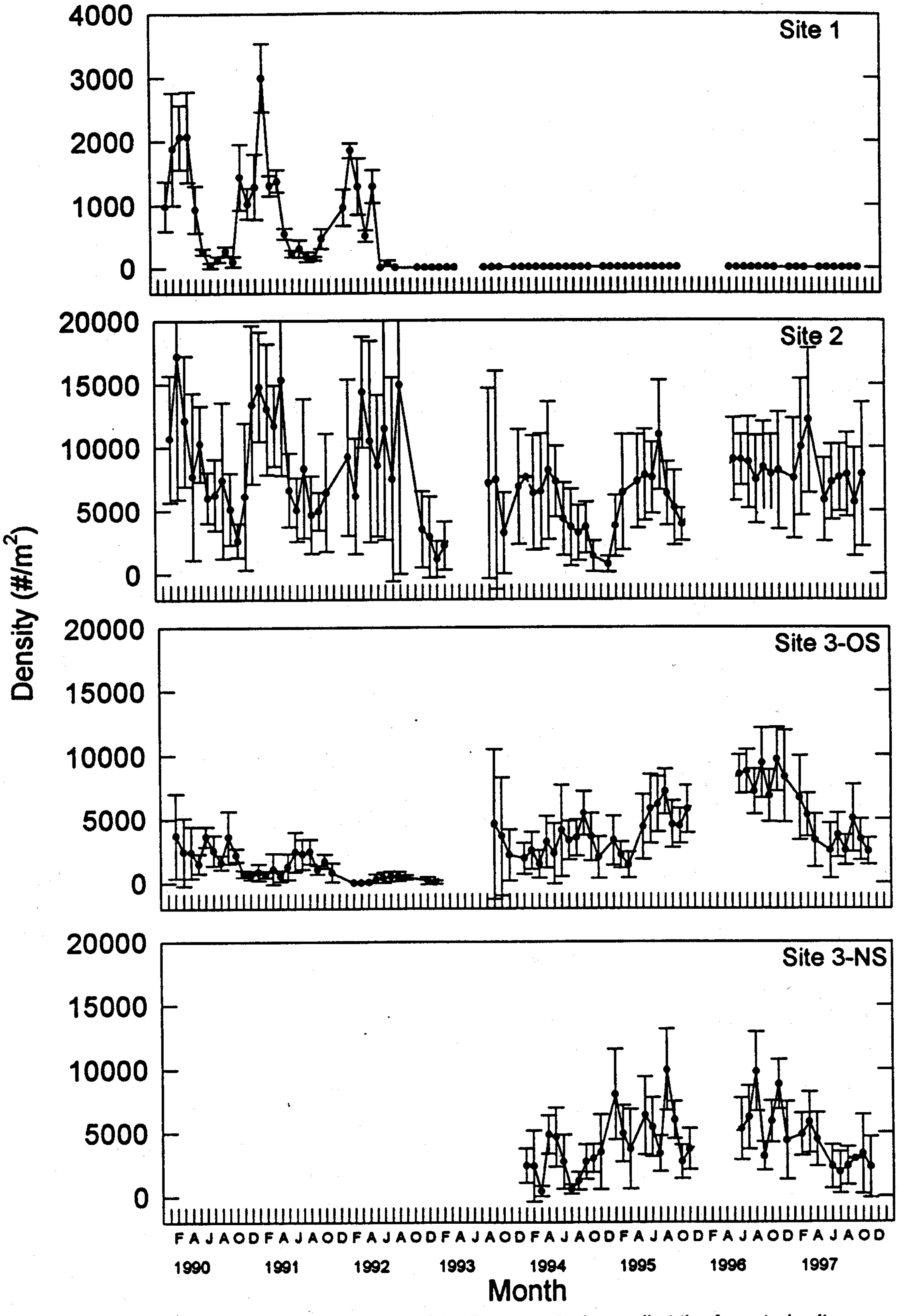

Figure 7. Mean density of the Bruneau Springsnail at the four study sites. Error bars represent one standard deviation from the mean. Note the different Y-axis for Site 1.

7). Typically, lower densities at Site 2 were found during colder months (September through February) (Fig. 7).

Site 3-OS (Lower spring rockface)

In 1997, the Site 3-OS Springsnail population maintained fairly constant densities between the months of February and November. With the exception of 1992 and 1996, densities were within the range of data from previous monitoring years (Fig. 7). The highest snail density at this site was 6628 snails/m^2 in February while the lowest density was 2416 snails/m^2 in November (Fig. 7).

Site 3-NS

Snail densities at Site 3-NS were generally lower than those at Sites 2 and 3-OS (Fig. 7). In 1997, the highest density, 5789 snails/m^2, was recorded in March and the lowest density, 1862 snails/m^2, was recorded in July. Densities in 1997 were within the range of values estimated in previous years (Fig. 7). Currently, Site 3-NS does not provide a habitat suitable for large populations of Springsnails because of its small rockface area, large amount of shading, and diffuse groundwater flow. Still, this seep does support a viable population. Improvement in habitat (e.g. augmentation of groundwater flow) probably would result in increased density and total population numbers.

Discharge, Temperature, and Water Chemistry Fluctuations

Site 1 (Hot Creek)

Hot Creek discharge dropped after channel scouring and sediment loading in July 1992 (Fig. 8). Discharge after the start of 1993 fluctuated greatly, probably as a result of precipitation (Fig. 8). Reduced discharge in Hot Creek resulted in higher maximum water temperatures for 1992 (Mladenka 1992). This relationship did not hold as strongly between 1993 and 1996 (Fig. 8). Extreme temperatures at Site 1 prior to September 1994 (date when minimum-maximum thermometers were replaced with submersible temperature data loggers) may have been the result of

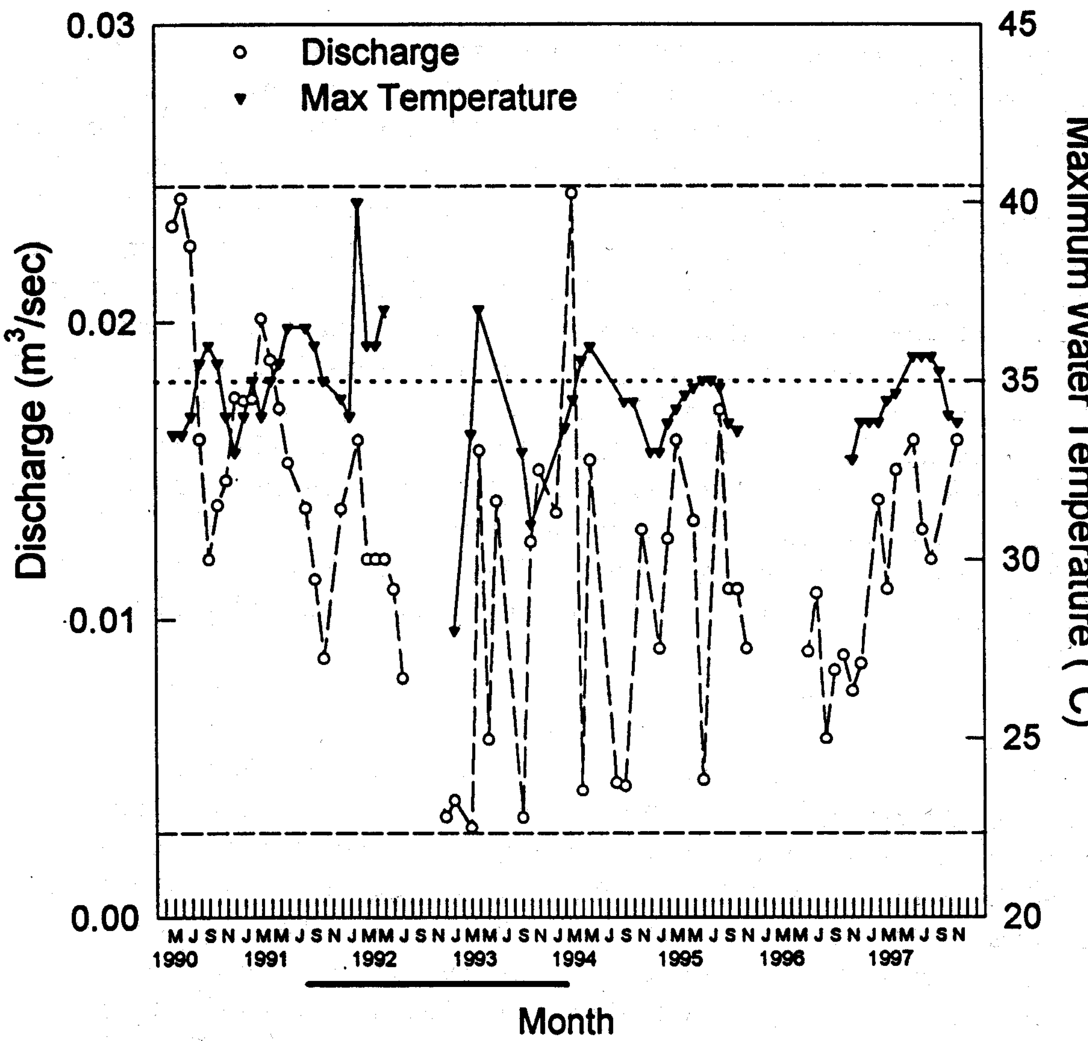

Figure 8. Discharge and maximum water temperatures for Site 1 (Hot Creek). Dashed horizontal lines indicate the maximum and minimum discharges measured at Hot Creek. Dotted horizontal line indicates thermal maximum temperature for *P. bruneauensis*. Dark bar under x-axis represents probable outlier period for temperature. See text for additional comments.

thermometer exposure to air (Fig. 8, 9; Royer and Minshall 1993, Varricchione and Minshall 1997). Water temperatures in 1997 ranged from 32 to 36°C, which is consistent with trends after September 1994 (Fig. 9). There was no apparent change in water chemistry at Site 1 during 1997 (Fig. 10), although, there was an increase in hardness during the month of June.

Site 2

At the left seep in 1997, the percent springflow-covered (SFC) rockface ranged from 10 to 30% (Fig. 11 top). The percent rockface-wetted-but-lacking flow (W/LF) in 1997 ranged from 95 to 100%, which was slightly higher than previous years (Fig. 11 bottom). At the right seep, the percent SFC rockface in 1997 fluctuated 5 and 25%, which was lower than previous years (Fig. 11 top). In 1997, percent rockface W/LF at the right seep ranged between 95 and 100%, which was generally higher than previous years (Fig. 11 bottom). Very low water temperatures at Site 2 in 1993 were probably the result of thermometer exposure to air (Royer and Minshall 1993). Site 2 maintained relatively constant temperatures during 1997 (Fig. 9). Minimum temperatures (31°C) were recorded in April and maximum temperatures (35°C) were recorded in July through October (Fig. 9). Water chemistry for 1997 was similar to values from previous years (Fig. 10).

Site 3

The percent SFC rockface for Site 3-OS in 1997 ranged from 8% in September to 30% in June, and agreed with data from previous years (Fig 11 top). The percent rockface W/LF in 1997 ranged between 95 and 100%, which also agreed with data from previous years (Fig. 11 bottom). Very low water temperatures at Site 3-OS in 1993 were probably the result of thermometer exposure to air (Royer and Minshall 1993). In 1997, temperatures varied widely, as in other years, from 19 to 31°C (Fig. 9). Water chemistry for 1997 was similar to values from other years (Fig. 10). However, there was a slight increase in hardness in September of this year.